

## DEVELOPMENT OF DIFFERENT RENEWABLE ENERGY BASED COLD STORAGE UNITS FOR JAMMU AND KASHMIR STATE

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### ABSTRACT

*Jammu and Kashmir is a horticultural based economy with most revenue coming from horticulture produce. The fruit growers of Kashmir are witnessing losses and exploitation, because of unavailability of cold storage units at source (i.e. on-farm). The inefficiency in the logistic system includes physical inadequacies and multiple handling of produce. Inadequate cold chains lead to high wastage and bunched-up supply. A majority of Kashmir's villages has an erratic power supply and in future too conventional electricity doesn't seem to be too useful for running cold storages in Kashmir. Hence there is a need for small cold storage facilities that are not dependent on the grid electricity and need to temporarily store the farm produce till market prices are more amenable to small farmers. Since J&K is blessed with perennial solar energy and a lot of surplus biomass resources, renewable energy based cold storage units can help meet this shortage using abundantly available renewable energy that is best suited for rural/ decentralized deployment. The present paper shows light on such renewable energy based technologies useful for J&K state which will be used to operate small, decentralized cold storage right at the village level which would also supply grid quality power to the village, thereby offering a holistic solution to some of the key problems of Jammu and Kashmir's horticulture industry and rural sustainable development.*

**KEYWORDS:** Renewable Energy, Cold Storage, Solar Photovoltaic, Solar Thermal, Concentrated Solar Technology, Biomass, Gasification, Hybridization, Cogeneration & Horticulture

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### INTRODUCTION

Horticultural sector contributes immensely to strengthen the financial condition of Jammu and Kashmir. The Horticulture sector plays an important role in the State, being the important source of State Economy and also source of livelihood for substantial portion of the population of the J&K State. About more than seven lakh families are directly or indirectly involved and dependent on the Horticulture Industry. J&K State has been declared as Agri Export Zone for Apple and Walnut Horticulture Produce. Horticulture is the important source of GDP on account of the fact that against the production of 1.83 MTs in 1972-73 the production has risen to the level of 24.94 LMTs which raised the turnover of Rs. 6000.00 crores approximately during 2015-16[1]. Apple cultivation is highly profitable economic activity in the state, which is famous for its quality apple. It is farm-based, labour intensive and commercially attractive economic activity. The income per acre is much higher than any other horticultural crops, if it is done in a systematic way. The Apple production plays an important role in improving the standard of living, per capita income and employment generation. More than half percentage of the population is engaged in the cultivation of apple, directly or indirectly in the state. [2] The improvement in

production is quite important, but the marketing has equal importance to develop a commercial crop. It has been found that the farmers face numerous problems, however the major problem associated with apple cultivation is post-harvest losses including undeveloped cold storage facilities. More than 99 percent of horticultural production is confined to rural areas and these areas are mostly inaccessible or without proper electricity.

Kashmir is located farthest from the terminal market as compared to Himachal Pradesh and Uttaranchal. This increases the cost of carrying fruit to the mandies. Further the supporting infrastructure like roads are either inadequate or in poor shape and cold storage (CA) stores or cold chain for maintaining and preservation of quality of fruit is not available to regulate the supplies. This decreases the value of the crop (apples) and also other perishable fruits like strawberries, cherry and pears etc. The fruit growers of Kashmir are witnessing losses and exploitation, because of unavailability of cold storage units at source (i.e. on-farm). The inefficiency in the logistic system includes physical inadequacies and multiple handling of produce. Inadequate cold chains lead to high wastage and bunched-up supply. The inadequacy in cold chains fails to smoothen out the supply which is seasonal in relation to the demand which is constant and results in huge losses.

Most of times, farmers of Kashmir have to resort to distress selling due to limited shelf life of the produce in the absence of access to even short-term cold storage facilities. As a result, marginal and small farmers face difficulty in getting good returns from sales of their horticultural produce. Furthermore, a majority of Kashmir's villages has an erratic power supply and in future too conventional electricity doesn't seem to be too useful for running cold storages in Kashmir. Hence there is a need for small cold storage facilities that are not dependent on the grid electricity and need to temporarily store the farm produce till market prices are more amenable to small farmers. Since J&K is blessed with perennial solar energy and a lot of surplus biomass resources, renewable energy based cold storage units can help meet this shortage using abundantly available renewable energy that is best suited for rural/decentralized deployment.

The time has come when J&K has to develop cold storage units with indigenously available biomass and solar resources. The same could be used to operate small, decentralized cold storage right at the village level (as opposed to commercial, large-capacity cold storages at centralized locations). In addition to providing the cold storage facility to the farmers, such a system is to be envisaged which would also supply grid quality power to the village, thereby offering a holistic solution to some of the key problems of Jammu and Kashmir's horticulture industry and rural development.

### **COLD STORAGE UNITS BASED ON DIFFERENT RENEWABLE ENERGY SOURCES RECOMMENDED FOR JAMMU AND KASHMIR**

Jammu and Kashmir has a very good potential for solar energy, with average solar irradiation around 4-7 kWh/m<sup>2</sup>/day. This abundant solar radiation can be used to meet the demand of low to medium process heat required by various industries and institutions including horticultural industry. Concentration of solar radiation to produce the temperature in the range of 100 to 450°C or more is called concentrated solar thermal (CST) technology. This technology offers sizable potential across a diverse range of industries and commercial establishments in India. CST technologies are mostly preferred worldwide for process heat and cooling through refrigeration cycles.

There are six CST technologies commercially available in India, namely,

- Fixed focus automatically tracked elliptical dish (Scheffler)
- Dual axis tracked paraboloid dish

- Fresnel reflector based dish (ARUN dish)
- Single axis tracked parabolic trough concentrator
- Non-imaging concentrators
- Linear Fresnel reflector.

Jammu and Kashmir is blessed with diverse agro -climatic zones. The different technologies of CST as mentioned above can be used based on location and needs.

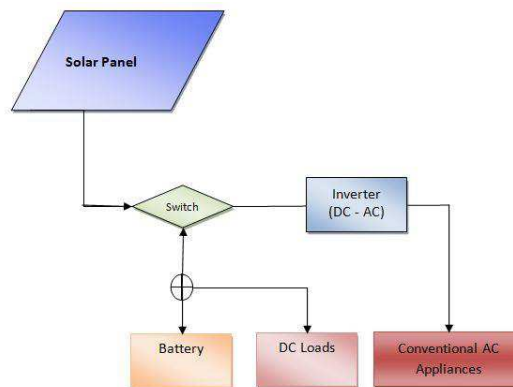
Refrigerant systems for cold storage are applied to processing, manufacturing and warehousing food, biomedical waste, ice manufacture, and other uses, but the largest application is for refrigeration and freezing of foods. The refrigerated system provides much lower temperatures than comfort air-conditioning systems. The selection and design of a mechanical refrigeration system should be economical, safe, reliable and simple. A design should be indicative of the refrigeration industry's trends, with emphasis on simplicity and low maintenance. There are essentially two refrigerant system designs utilized in the cold storage refrigeration market, i.e., direct expansion and liquid circulation. The dominant design is a field constructed ammonia liquid recirculation system screw compressors and evaporative condensers. Normally the capacity of a cold storage unit is expressed in terms of its storage volume. This capacity is related to the product to be stored and the plant capacity is measured in terms of its tonnage. The Cold storage plant process is simple and well established. Ammonia refrigeration is cheap and is of high latent heat of evaporation.

Major parts of Jammu and Kashmir are encountering problems of electricity, irrigation and cold storage infrastructural facilities. The immediate perspective is to make available at least bare minimum energy services to the rural people. The technology, which does the trick convincingly in the remote rural environment, is biomass gasification. Therefore, biomass based gasifiers power plant and utilization of waste heat (exhaust) of biomass producer gas engine for cold storage may be the most appropriate technology for the development of rural India. However, based on DNI and GHI data through solar resource assessment of J&K state, photovoltaic based cold storage units can also prove to be effective in low cold storage units.

The following Renewable Energy based cold storage units are recommended for the J&K state.

#### **Cold Storage Unit based on Photovoltaic System**

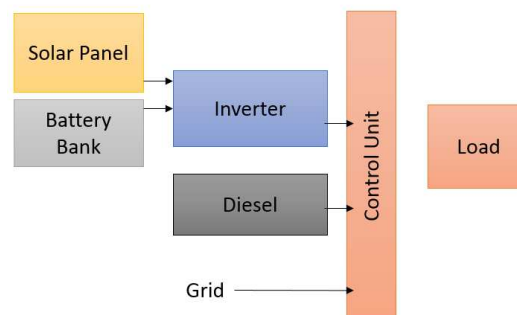
Jammu and Kashmir is blessed with a fair amount of Global horizontal irradiance. Lowest ambient temperature with less wind velocity makes photovoltaic technology as one of the suited renewable energy technologies for electricity. The same electricity can be used to run cold storages. This electricity can be useful near on-farm produce in rural areas which have the highest potential of horticulture produce. Since these areas are either inaccessible or electricity isn't readily available, Photovoltaic energy can be used as a standalone system or can be used with existing electricity in these areas. The energy (electricity) is used for refrigeration like other conventional methods and the system consists of Solar PV modules, long life, low maintenance batteries, solar inverter cum charge controller and suitable wire. Solar power from the photovoltaic cells in case of cold storage chamber/container/van is utilized mainly to drive the compressor of the system.



**Figure 1: Cold Storage Based on Solar Photovoltaic System**

### Solar Photovoltaic + Diesel Gen Set Hybridization based Cold Storage

In many parts of country and in J&K state, some of the cold storage units run on diesel especially in Leh and Kashmir. The diesel gen sets not only pollute environment but have also proven to be expensive. For such areas which are inaccessible or where traditional electricity isn't supplied to desired limits, Photovoltaic plants can be hybridized with diesel gen sets. This will ensure less consumption of diesel as well as will help in sustainable development of the area. In such cases, a solar PV can be coupled with existing DG set to supply electricity for base load. During day time, solar photovoltaic energy can be utilized to run such cold storage units and in evening when there is no sun, battery storage energy can be utilized to run such cold storage units. in case of low output through battery, the same diesel gen sets may be used to offset energy from battery.



**Figure 2: Solar Photovoltaic + Diesel Gen Set Hybridization based Cold Storage**

### Solar Photovoltaic + Solar Thermal Hybridization based Cold Storage

With an average DNI and GHI received from last ten years varied from (1 kWh/day/m<sup>2</sup>) to (8 kWh/day/m<sup>2</sup>) per day. Jammu and Kashmir has bright scope for both photovoltaic and solar thermal technologies. During winter months, when there is low sunshine or less sunshine hours, solar photovoltaic energy can be hybridized with solar thermal energy and shall generate electricity as well as maintain the required temperature, with the help of Phase Change Material so as to maintain the required temperature and minimise the load on the compressor which is driven by the electricity produced by solar photovoltaic only. in this case either direct cooling can be achieved by solar thermal energy through PCM mode or else cooling can be achieved through indirect method by using VAM.

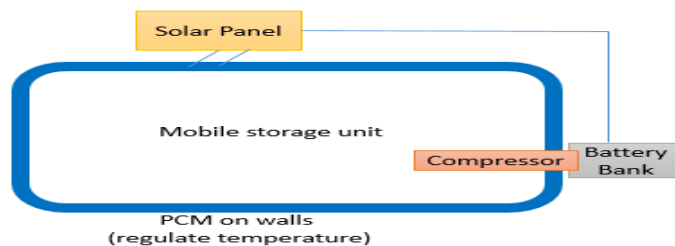


Figure 3: Solar Photovoltaic + Solar Thermal Hybridization Based Cold Storage

### Solar Thermal Energy based Cold Storage

GHI is an important factor to determine efficiency for photo voltaics, while DNI is of special importance for solar thermal applications. Since J&K is receiving a good amount of sunshine with a fair amount of the DNI in Jammu and Kashmir and Highest DNI in Leh division, Solar thermal based cold storage units can be encouraged on a large scale. Solar thermal technology for process heat and cooling is preferred over the PV system based cold storage units as it can utilize more incident sunlight than a PV system. A solar thermal refrigeration system consists of four major components: a solar collector array, a tank for thermal storage, a thermal AC unit and a heat exchanger. The thermal collector receives the light energy from the sun and increases in temperature; as a result, the refrigerants inside the collector evacuated tubes become hot through a heat convection process. The thermal storage tank is used for storing the hot refrigerants from the collector tubes. Refrigeration majorly in case of large cold storage units has to be done by Vapor Absorption Machines (VAM). The hot water (feed) for VAM can be provided by Solar Water Heater and gas geysers hence saving a lot of electricity for the purpose of refrigeration.

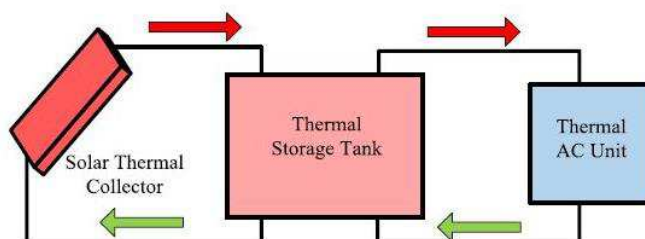
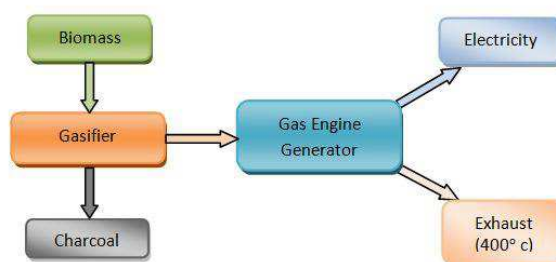


Figure 4: Solar Thermal Energy based Cold Storage

### Biomass Gasification (Gasifiers) based Cold Storage

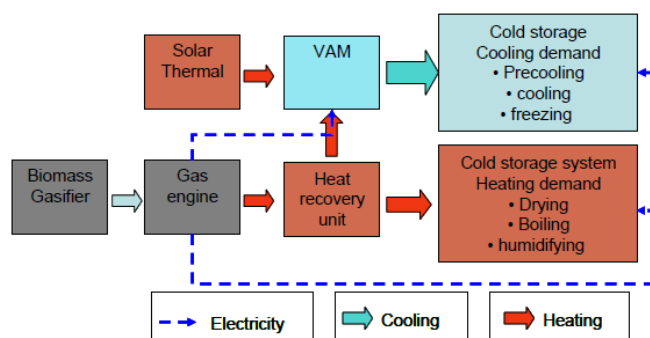
Gasifier based cold storage unit can be a success story in cold storage development in Jammu and Kashmir as the state is blessed with huge biomass potential. Residues, walnut residues and forest waste can be used for biomass gasification along with wood based biomass, briquetting and other bio energy sources. However, among all these major biomass based energy sources, one of the best available fuel is horticulture waste. Jammu and Kashmir has highest apple cultivation in India and the same apple has to be stored in cold storage for better pricing and to increase its shelf life. Since, traditional electricity cannot sustain such units as it is not available 24x7 in these areas. However, pruning of apple trees in winter can be used as biomass for gasification process and same can provide electricity as well as heating in winter. Biomass Gasifier based electricity generating systems are a viable option for decentralized electricity production, especially in village areas where the grid is not available and lots of available biomass is readily available.



**Figure 5: Biomass Gasification (Gasifiers) based Cold Storage**

### Solar-Biomass Hybridization based Cold Storage

This cogeneration technology can be best suited for the state of J&K as it will not only produce electricity but can also provide heating through process heat and can run cold storage units either through available electricity through biomass gasification or thorough available solar field (CST technology) and even through waste heat generation. A Vapor Absorption Machine (VAM) is driven on the engine waste heat which otherwise would have been rejected and wasted otherwise. The solar thermal collectors used in the configuration supplements the heat to the vapor absorption system during day time, when it may not be required to operate the electricity generating system. Direct firing of biomass may also be made available with biomass gasifiers for direct usage of cold storage during the night.



**Figure 6: Solar-Biomass Hybridization based Cold Storage**

## CONCLUSIONS

Horticulture has been back bone of J&K's economy. Even during turbulent times and violence in state when tourism foot prints were low, horticulture sustained major portion of J&K's GDP. There is immediate need to develop cold chains for horticulture industry in state as approx. more than 30 percent of losses are incurred as post-harvest losses and a major reason is unavailability of cold storage units at on-farm source There are various renewable energy technologies which can be integrated within the cold chains as Government of India is also providing incentives for integrating Renewable Energy through various schemes of Ministry of New & Renewable Energy(MNRE), Ministry of Food Processing, Ministry of Agriculture and National Horticulture Board besides J&K along with north east states been given highest subsidies by respective ministries as special and hilly states.

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